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(54) Combined microwave and forced convection oven.

(57) The present invention relates to an oven for food cooking, particularly for community kitchens, wherein two or more magnetrons arranged externally to the side walls propagate the microwave radiation from the entire height of said side walls toward the interior of the cooking chamber affecting a plurality of food containing pans or shelves contemporaneously present inside said cooking chamber and disposed one atop the other at different heights.

An oven capable of achieving the cooking function in the microwave mode and contemporaneously in the forced convection and/or steam mode for the foods contained in said plurality of superposed pans.

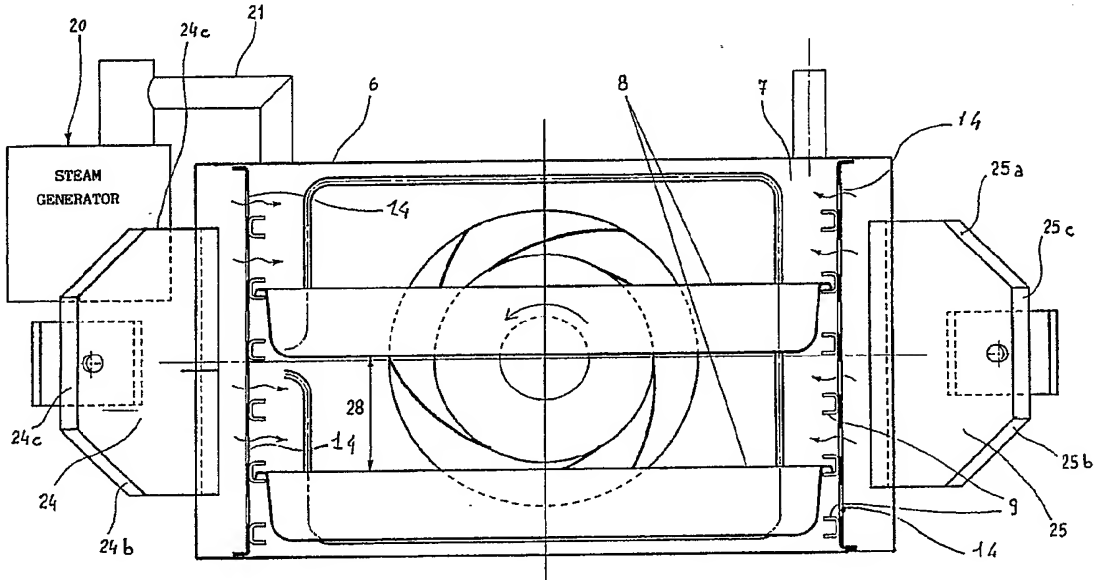

FIG. 1

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COMBINED MICROWAVE AND FORCED CONVECTION OVEN

This invention relates to a microwave and forced convection or steam oven with gas or electric heating of the food disposed in the cooking chamber of the oven.

Forced convection ovens with gas or electric heating of the food, particularly utilized in the community kitchens (schools, hospitals, mess halls, and so on), are well-known, these types of ovens consisting essentially of an exterior metal casing enclosing a cooking chamber through which a motor-driven fan creates a flow of hot air which, in the case of a gas oven, is mixed with the combustion gas produced by a burner located in a corresponding combustion chamber communicating with both said cooking chamber and the exterior of the oven and, in the case of an electric oven, is heated by corresponding electric heating elements located inside the cooking chamber itself.

These gas or electric ovens, due to the direct heating of the food, allow a shorter cooking time as well as a higher thermal efficiency. In addition, in the case of a gas oven, the circulation of the combustion gas through the food assures that meat, fish and the like can be grilled in a more satisfactory manner.

Forced convection ovens with gas or electric indirect heating of the food are also well-known, these ovens consisting essentially of at least one heat exchanger housed, together with a fan for the hot air flow, in a further oven chamber, separate from the cooking chamber, but in communication with it, said heat exchanger being composed - in the case of a gas oven - of a group of tubular conduits conveying the combustion gas and connected with both the combustion chamber and an exhaust outlet and - in the case of an electric oven - of a plurality of electric heating elements. These ovens, due to their well-known characteristic of temperature uniformity within the cooking chamber, are particularly suited for cooking food contained in pans, chiefly metal pans, arranged one atop the other on different levels throughout the height of the cooking chamber. Therefore, with this type of ovens it is possible to contemporaneously cook the food contained in a plurality of pans, each one of them taking up the entire inner area of the cooking chamber.

Combined microwave and thermal ovens which achieve the simultaneous cooking according to the foregoing description are well-known as it is also well-known the excellent fast cooking performance attainable with such a type of ovens. However, due to the opacity of the metal to the microwave radiation, generally it is possible to treat with microwave radiation only the food contained in that pan which is directly exposed to the microwave source since the other pans, being "obscured" by the first pan, will not be exposed to the radiation source. Further, even if the pan is not made of metal, but of another material transparent to the microwaves, as for instance certain types of ceramic, the food contained in that pan which is directly exposed to the radiation will actually absorb most of the irradiated energy with the consequence that the food contained in the other pans would not be cooked properly.

Therefore, with this type of ovens it is possible to heat with both the thermal and microwave modes only one pan at a time.

Combined microwave and thermal ovens which cook the food contained in a plurality of pans arranged one atop the other inside the cooking chamber of the oven are also well-known (e.g. as claimed in the European patent No. 0068161, priority 20-6-1981).

However, in these ovens the magnetrons are mounted above the cooking chamber and the microwaves are directed toward the latter by one or more waveguides vertically disposed on the cooking chamber side walls thus cater-corner irradiating the pans through a plurality of spaced microwave slots.

This type of ovens present however the following disadvantages:

- The vertical waveguides take up a considerable serviceable space inside the cooking chamber.
- The established levels at which the various microwave slots are placed Therefore, it is desirable and it is an object of this invention to provide an oven capable of contemporaneously carrying out cooking programmes both in the thermal and microwave modes, utilizing a plurality of pans, also metal pans, set one atop the other throughout a significant height of the cooking chamber thus taking up the entire volume of said cooking chamber, and capable of ensuring a remarkable radiation uniformity on different planes as well as on different zones of the same plane so as to attain all of the aforesaid advantages that this type of cooking implies. This cooking oven is achieved with the constructive features substantially described herein and with particular reference to those set forth in the appended claims.

This invention will be best understood from the following description given by way of non-limiting example when read in connection with the accompanying drawings, in which:

- Fig. 1 is a schematic front view of a cooking oven according to a first embodiment of this invention;
- Fig. 2 is a top view of the oven shown in Fig. 1;
- Fig. 2a is a front view of a variation of the waveguide system from the magnetrons to the cooking chamber;
- Fig. 2b is a top view of the same variation;
- Fig. 2c and 2d are respectively a front view and a perspective view of the side wall of the cooking chamber showing a preferred arrangement of the microwave slots;
- Fig. 2e is a perspective view of the same detail with an alternative arrangement of the slots;
- Fig. 3 is an elevation external plan view of a construction detail of the oven shown in Fig. 1;
- Fig. 4 is a horizontal sectional view of the construction detail shown in Fig. 1;
- Fig. 5 is an elevation side projection of the construction detail shown in Fig. 3;
- Fig. 6 is a perspective view of a side wall of the cooking chamber;
- Fig. 7 is a schematic front view of a detail of the gas discharging chimney of a combined gas heated oven according to an improvement of this invention;
- Fig. 8 is a horizontal view of the motor-fan coupling according to a further improvement of this invention;
- Fig. 9 shows the detail of Fig. 8 after the fan has been removed.

With reference to Fig. 1 and 2 showing a forced convection and microwave cooking oven utilized for community kitchens, it can be seen that it substantially consists of a metal casing 6 enclosing a cooking chamber 7 in which are housed some special shelves or pans 8 set one atop the other, on which the food to be cooked is placed, said shelves being inserted and removed in an advantageous way with respect to the side guides 9 of the cooking chamber 7, previous opening of the oven front door 10.

Said cooking chamber 7 is subdivided into a further inner chamber 11 by a partition wall 12 extending along the entire height and part of the width of the cooking chamber, the latter being in communication with said inner chamber 11 by means of some side openings 14 and a central opening 15a provided on the partition wall 12 for the hot air circulation, the inner chamber 11 being provided with a centrally disposed fan 15 driven by a coaxial electric motor 16 mounted externally against the rear wall 17 of the oven. The fan 15 is laterally delimited by a group of tubular conduits 18 arranged close to its circumferencial edge, said tubular conduits 18 being properly bent so as to encircle said fan 15 and being connected with their upper and lower ends respectively with one or more discharging chimneys located on the upper part of the oven and with a not indicated combustion chamber placed in the lower part of the oven and housing at least a conventional gas burner.

In this way, when the combustion gas, to be discharged outside the oven through the upper chimney, is flowing inside said tubular conduits 18, the latter are acting as a heat exchanger so that the heat produced can be utilized for indirectly heating the food by a flow of hot air uniformly distributed throughout the entire cooking chamber 7 by the action of the fan 15.

An electric heating as an alternative to the gas heating can be achieved by arranging suitable resistors, preferably circular resistors, around the periphery of the fan 15.

Further, the cooking oven, can possibly be connected to an external steam generator as a boiler 20 or similar item, communicating through a duct 21 with the inner chamber 11 or even directly with the cooking chamber 7, with the purpose of determining the cooking of the food by means of metered quantities of steam introduced inside said cooking chamber, or by means of the combined action of steam and forced hot air circulation. The microwave heating is obtained by disposing externally and symmetrically to the cooking chamber 7 two magnetrons 22 and 23, said magnetrons being connected to said cooking chamber by two corresponding lateral and symmetric trumpets 24 and 25 which cover the respective magnetrons and have the triple aim of avoiding the escape of radiations to the exterior, of guiding the radiations toward the cooking chamber and of containing a special propagation mixing device 26, 27 well-known from the state of the art as a "stirrer".

It is well-known that the stirrers, during the magnetron operation, are kept continuously in a rotational condition by appropriate motors 29a and 29b. It has been experimentally proved that with a proper combination of the shape, size and position of the trumpets and of the shape, size and position of the stirrers it is possible to deflect the radiations emitted by the two magnetrons along a radiation field which propagates in a substantially plane and uniform manner from the full height of the two side walls toward the interior of the cooking chamber.

The shape and size of the trumpets are illustrated in claims 4 and 5, while their position is indicated in Fig. 1 and 2.

The shape of the stirrers is described in one of the claims, while their position inside the trumpets is shown in Fig. 2, 3, 4 and 5.

It has been found that if some pans (two of them at least) are introduced inside the cooking

chamber so as to take up the entire available area and they are so disposed one atop the other so as to leave a clearance 28 between the bottom of the upper pan and the top of the lower pan equal to at least to a half-wave as indicated in Fig. 1, the propagation coming from the walls penetrates said clearance and hit uniformly the food contained in the lower pan.

As a result, said clearance practically becomes a new and smaller cooking chamber contained in the original cooking chamber, the former being delimited up and down respectively by the bottom of the upper pan and the bottom of the lower pan.

Therefore, if a plurality of pans are inserted at a proper height one from the other, smaller adjacent cooking chambers are created, all of them being hit by the microwave propagation.

In short, by inserting some pans horizontally and at a suitable height one from the other so as to take up all the available inner space, as many cooking chambers are created in which the cooking of the food contained in each pan can be effected contemporaneously both in the heating and microwave modes.

The shape, size and position of said trumpets 24 and 25, the shape, size and position of the corresponding stirrers and the orientation of the magnetrons are shown in Fig. 1, 2, 3, 4 and 5.

A variation to this solution is shown in Fig. 2a, 2b, 2c and 2d.

With reference to these figures, it can be seen that the two magnetrons 22 and 23 are placed over but however externally to the side walls and in a central position with respect to said cooking chamber. The radiations emitted by said magnetrons is guided by two downwardly oriented, symmetrical and vertically disposed waveguides 50 and 51, substantially extending down to the bottom 52 of the cooking chamber, the walls 53 and 54 being facing the inside of the cooking chamber constituting an integral part of the respective walls 55 and 56 of said cooking chamber, so that the walls 53 and 54 are part both of the walls of the respective waveguides and of the corresponding cooking chamber walls.

As shown in Fig. 2c and 2d, the walls 53 and 54 of said vertical waveguides 50 and 51 are provided with a series of substantially similar inclined slots 55, 56, 57, 58, 59 from which the microwaves propagate toward the interior of the cooking chamber, said slots being equally spaced one from the other in such a way that a slot terminates where the next one starts.

In this manner the following advantages are obtained:

a) Substantial reduction of the overall width dimensions of the oven due to the fact that the magnetrons are moved from an external side position with respect to the cooking chamber to a higher position;

b) Cost reduction due to the elimination of both the stirrers and their related motors;

c) Improved reliability.

No particular disadvantages are set against the aforesaid advantages because the special configuration of the slots from 55 to 59 allows the microwaves to propagate from the entire height of the waveguide and therefore from the entire height of the cooking chamber thus attaining the objective of cooking the food placed in superposed pans which practically take up the entire height of said cooking chamber.

A further modification of the configuration of the slots from 55 to 59 is shown in Fig. 2c, where it can be seen that said slots, even if still inclined, are however parallelly disposed.

The just described oven is fit to attain the wanted result of performing a microwave cooking programme in a cooking chamber housing a plurality of pans set one atop the other. Nevertheless, it still remains the problem consisting in the fact that it is not possible to superpose the pans without carrying out some other modifications. In fact, as a rule, the pans are introduced into the cooking chamber 7 by fitting their borders onto horizontal metallic guides parallelly disposed at different heights on both side walls of said cooking chamber.

It is apparent that if the cooking chamber is designed according to this invention, the radiations which propagate from the trumpets 24 and 25, will directly hit said guides and, being by them obstructed at once, they will also create the conditions for a serious congruity impairment between the cooking chamber and the two trumpets.

Moreover, in the larger ovens, especially in those utilized for community kitchens, the forced convection takes place by drawing the air from a central opening provided on the rear wall of the cooking chamber and by blowing this air, after it has been heated, into said cooking chamber, through a plurality of slots 14 made on the side walls of said chamber, preferably on the entire height of said walls, said slots being obtained in the free space between the pan supporting guides 9 as shown in Fig. 6. It is apparent that this type of structure is inconsistent with the direct utilization of this invention since the guides 9 and the air ducts present on the side walls would originate a very serious obstacle to the normal microwave propagation.

To avoid this hindrance, it has been found that a heat resisting and microwave-transparent material as for instance ceramic, polytetrafluoroethylene, polyether-etherketone, polysulfone or other material with similar characteristics can advantageously be

used for producing said guides.

A further improvement of this invention is the following: it is known that the microwave ovens must comply with the safety requirements set forth in the existing specifications and in particular to those specifications related to the emission of microwave radiations.

In a thermal and forced convection oven of the type hereinbefore described it can occur that the shaft 30 of the fan 15 placed behind the rear wall of the cooking chamber is protruding with its front end inside the inner chamber and therefore is acting, as a matter-of-fact, as an elementary receiving antenna.

If, as a rule, said shaft extends backward outside the rear wall of the oven, as it is shown in Fig. 2, said shaft becomes, as far as the propagation is concerned, a transmitting antenna which propagates outside the oven, the radiation that it picked up inside the inner chamber 7, thus affecting the safety requirements.

The known solutions to this problems are:

- Shaft partially or totally made of microwave-transparent material (for instance ceramic, which however implies a remarkable brittleness).
- Provide a chamber not concerned with the microwave radiation, where the shaft enters in the conventional way (e.g. by providing a convection cooking chamber back-cell in which the partition wall between the latter and the cooking chamber cannot be removed unless it is provided with a special choke, in which case it can be removed only by a technician).

However, these remedies present the inconvenience that they do not allow the access into said back-cell for performing the normal cleaning operations.

If it is wanted that said partition wall could be removed by the user, it would be then necessary to provide a safety circuit to preclude the oven operation when said partition wall is removed.

Furthermore, for performing a normal cleaning operation of the fan and of the cell in which it is housed, it is a common practice to withdraw said fan from the inside of the cooking chamber; in this case, if the fan is not remounted, the shaft of its related motor will protrude, as it normally occurs, inside said cell thus acting as a receiving antenna which picks up the radiations coming from the cooking chamber and retransmits them toward the motor and hence outside the oven.

As shown in Fig. 8, to avoid these further inconveniences, it has been found advantageous to have the metal motor shaft 30 crossing the wall of the cell in correspondence with a toroidal choke 31 consisting of a fixed cylindrical part 32 (welded to the cell itself) and a rotating part 33, the latter being integral with the rotating element, which can be made of metal.

The characteristic of said choke 31 is that its two component parts 32 and 33 resemble to two different sized small cups inversely inserted one into the other. The hollow space 31 forms a labyrinth for the microwave propagation and if the depth of said labyrinth exceeds a quarter of the wave length, then, as it is well-known, said labyrinth will act as an effective obstruction to the microwave propagation. moreover, to avoid that when the fan is removed, the shaft 30 could act as a receiving antenna, the diameter of the fixed cylindrical part 32 should be smaller or equal to a quarter of the wavelength and its depth longer than said limits, as indicated in Fig. 9.

A still further improvement of this invention can be achieved in the combined indirect gas heating and microwave ovens.

In this case, the heat is obtained by burning the gas inside a closed chamber located, as a rule, underneath the fan, and is conveyed into the cooking chamber by means of a heat exchange between the burnt gas exhaust conduits and the air and steam current which, being made to circulate by the convection fan, comes in contact with said conduits.

The latter are disposed, as a rule, at the sides of said fan (see Fig. 2) and, since the air inlets on the side of the cooking chamber are rather large, it comes out that the microwave propagation inside said cooking chamber penetrates into the back chamber where the fan and the conduits are located thus hitting them throughout.

At this point, it is evident that if said conduits have a free access to the exterior they will become "carriers", through the surfaces of which the microwaves are transmitted outside the oven due to the well-known "skin effect", thus impairing the safety requirements.

To avoid this occurrence, such an escape route can be blanked between said conduits and the wall which encircles them, said wall being in this case the upper cover of the oven; but the blanking operation, for instance the welding operation, besides being delicate and costly is not always possible since it may be necessary to maintain an air gap between said surfaces or because the concerned surfaces may require to be removable or independently expandable.

With the purpose of eliminating said serious inconvenience, it has been found that a special microwave surface escape blanking item can advantageously be used.

With reference to Fig. 7, said item 41 is substantially a gasket made of a very dense thin metal braided wire. This gasket is placed along the path

42 of the microwaves and in contact with the metallic surfaces 43 and 44, is capable of completely blocking the microwaves, allowing however a small gap for expansion between said surfaces. Another advantage of this item is due to the fact that it is extremely flexible and can fit or assume any shape without for this loosing its effectiveness. This type of item is currently available on the market under the commercial name of KNITEX.

With reference to Fig. 7, the burnt gas exhaust outlet 44, the metallic upper covering 43 of the oven, the Knitex microwave escape blanking gasket 41 and the gasket retaining flange 45 can be seen.

It is evident that the microwave radiation present in the lower zone of the shown figure cannot enter the passage 42 because it will be blocked by the gasket 41 which electrically connects the burnt gas exhaust outlet 44 with the oven covering 43.

It is understood that what has been described and illustrated herein by way of non-limiting example to be read in connection with the accompanying drawings may be subject to various modifications and structural changes without departing from the scope of this invention.

Claims

1. A combined microwave and heating oven, especially utilized for community kitchens, consisting of a cooking chamber (7), on the side walls of which two or more guides (9) for supporting the food containing pans (8) are fixed, a door (10) for closing said cooking chamber, two or more magnetrons (22, 23) for microwave generation and possibly corresponding motor-driven stirrers (26, 27) for mixing said microwaves while they are propagating in said cooking chamber, wherein the microwave propagation penetrates into the cooking chamber (7) vertically from the cooking chamber side walls or from median and symmetrical portions of said walls, said portions substantially extending along the entire height of said cooking chamber.

2. An oven according to the preceding claim, wherein the plurality of magnetrons (22, 23) is posizioned externally to the side walls of the cooking chamber at a height and depth substantially symmetrical with respect to said cooking chamber (7).

3. An oven according to the preceding claims wherein the trumpets (24 and 25) which convey the propagation coming from the emitters of the magnetrons to the interior of the cooking chamber (7) have a height substantially equal to that of said cooking chamber.

4. An oven according to the preceding claim, wherein each one of said stirrers (26 and 27) consists of a ring shaped as an extended rhombus made of reflecting material and a brace connecting two opposite vertexes of said rhombus, said stirrers being connected in the central zone of said brace with the horizontal rotation shaft.

5. An oven according to claim 1, wherein the magnetrons transmit the microwave propagation into the interior of the cooking chamber through a plurality of vertical waveguides (50, 51) downwardly oriented and symmetrically positioned in correspondence of said cooking chamber side walls, said waveguides being extending down the bottom (52) and being provided with a series of substantially similar inclined slots (55 to 59) equally spaced one from the other in such a way as to have the lower end of a slot placed at the same height of the upper end of the next slot.

6. An oven according to the preceding claim, wherein said slots (55 to 59) are disposed either parallelly to each other or alternately inclined with respect to a vertical line.

7. An oven according to any one of claims from 1 to 4, wherein the trumpets (24 and 25) have the shape of containers open toward the interior of the cooking chamber (7), the upper and lower corners of the trumpets being replaced however by inclined walls (24a, 25a and 24b, 25b) respectively, symmetrically disposed with respect to a horizontal plane passing through the centre line of said trumpets, said walls being inclined of about 45 degrees with respect to the upper wall (24c) and the external wall (25c) of said trumpets.

8. An oven according to the preceding claim, wherein the height (A) of said trumpets is about the double of their widths (L).

9. An oven according to any one of the preceding claims, wherein along the side walls of said cooking chamber a plurality of horizontal guides (9) are disposed, said guides being used as a support for corresponding food containing pans (8) and being made of microwave-transparent material, as for instance ceramic, polytetrafluoroethylene, polyether-etherketone, polysulfone, and so on.

10. An oven according to any one of the preceding claims, comprising also a vertical rear wall (12) which separates the cooking chamber (7) from a further cell (11), a fan (15) located inside said cell, utilized for the hot air and steam circulation between said cooking chamber and the heating means (18), a motor (16), connected through a transmission shaft (30) to said fan (15), wherein the mechanical coupling between said shaft (30) and the fan (15) is achieved by connecting said shaft (30) to a bushing (35) integral with the fan (15), the bushing being provided with a cylindrical profile (33), circumferencial to said shaft and fitted on the fixed cylindrical profile (32) obtained by means of an appropriate profiling of the rear wall of the oven, said shaft (30) being positioned in such a way as to have its end (36) not protruding beyond the edge (37) of the cylindrical profile (32), said coaxial cylindrical profiles (32, 33) being dimensioned in such a way that the cylindrical hollow space between said profiles has a length not lower than the microwave quarter-wave.

11. An oven according to the preceding claim, wherein the fixed cylindrical profile (32) has a diameter lower or equal to the microwave quarter-wave and a depth not lower than said value.

12. An oven according to any one of the preceding claims, in which the heating is obtained by the combustion of gas, the burnt gas being discharged outside the oven through burnt gas exhaust conduits or outlets (44) which are passing through a cell (11) obtained externally to the cooking chamber and communicating with the latter through at least an opening 15a, wherein the interconnection between the walls (43) of said cell (11) and said conduits or outlets (44) is achieved by interposing in each coupling (42) between said metallic surfaces (43 and 44) a gasket consisting of a properly shaped very dense thin metal braided wire electrically connected with the corresponding contact points of said metallic surfaces, possibly with auxiliary supporting means (45) so as to completely close in a lasting manner each one of said couplings.

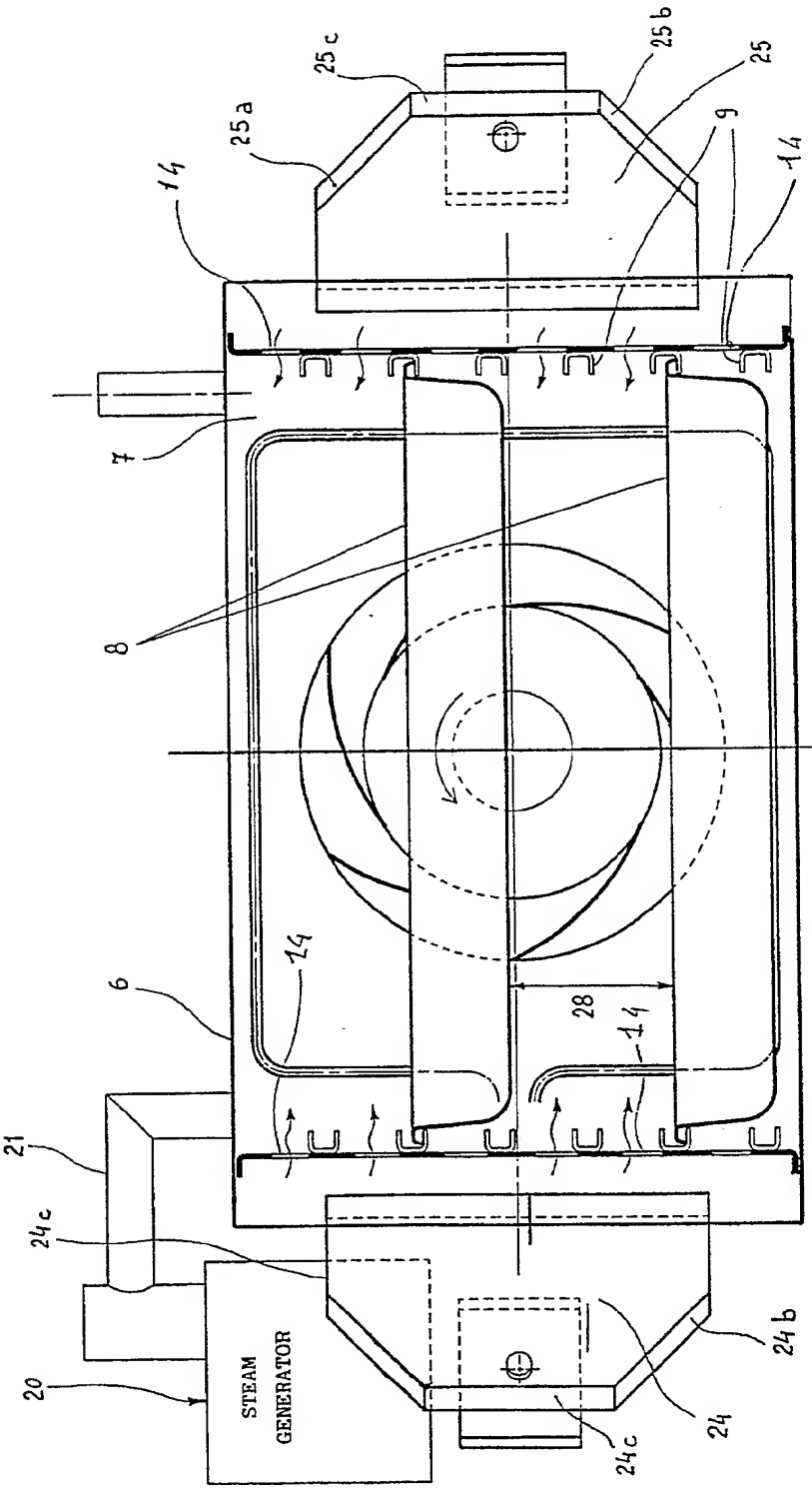
25c
25b
25
25a
9
14
14
7
8
14
6
28
14
21
24c
STEAM
GENERATOR
20
24b
24
24c

FIG. 1

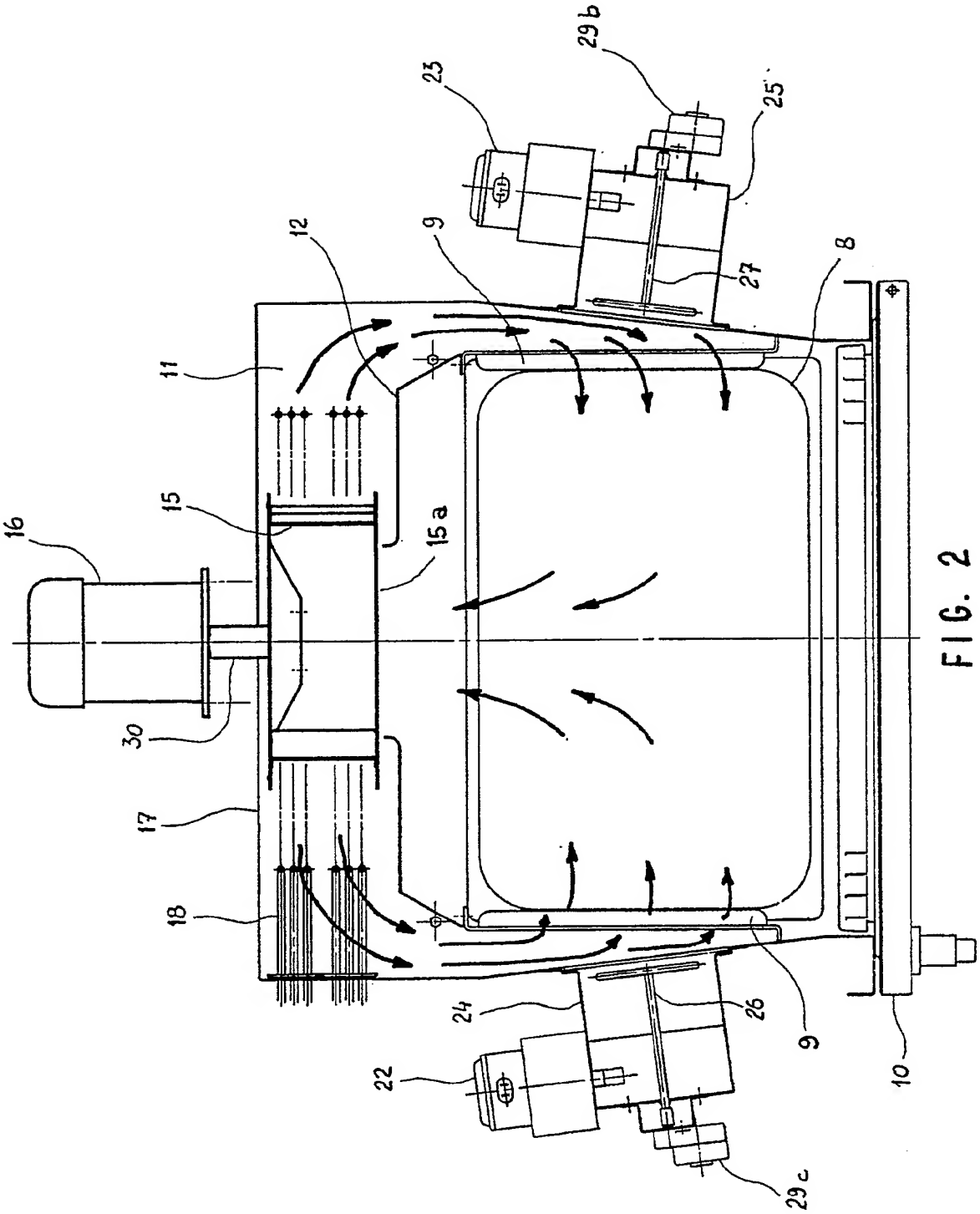

FIG. 2

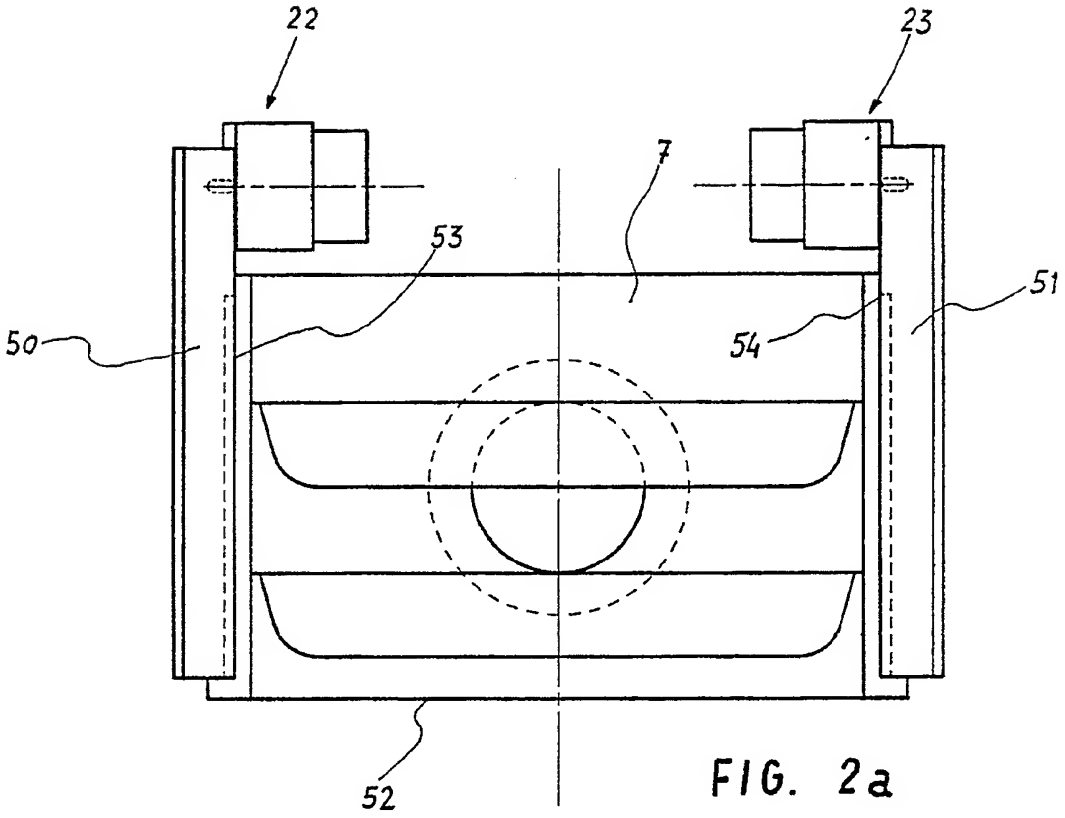

FIG. 2a

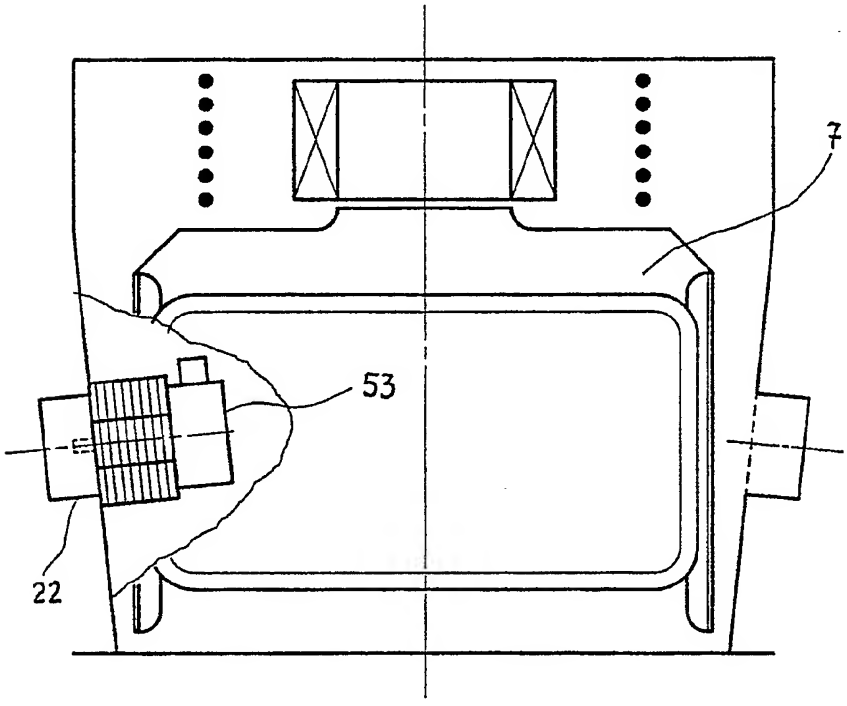

FIG. 2b

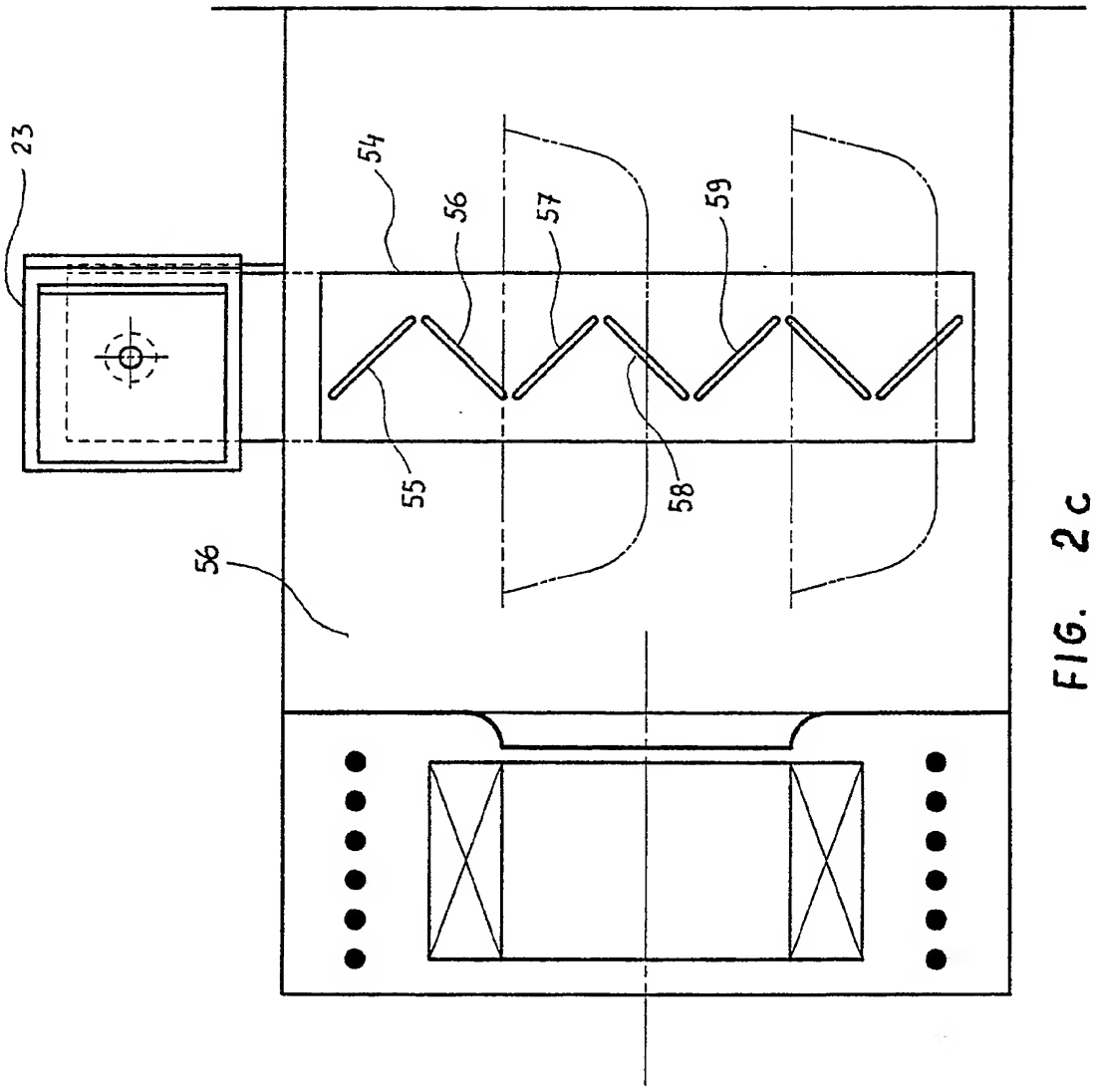

FIG. 2c

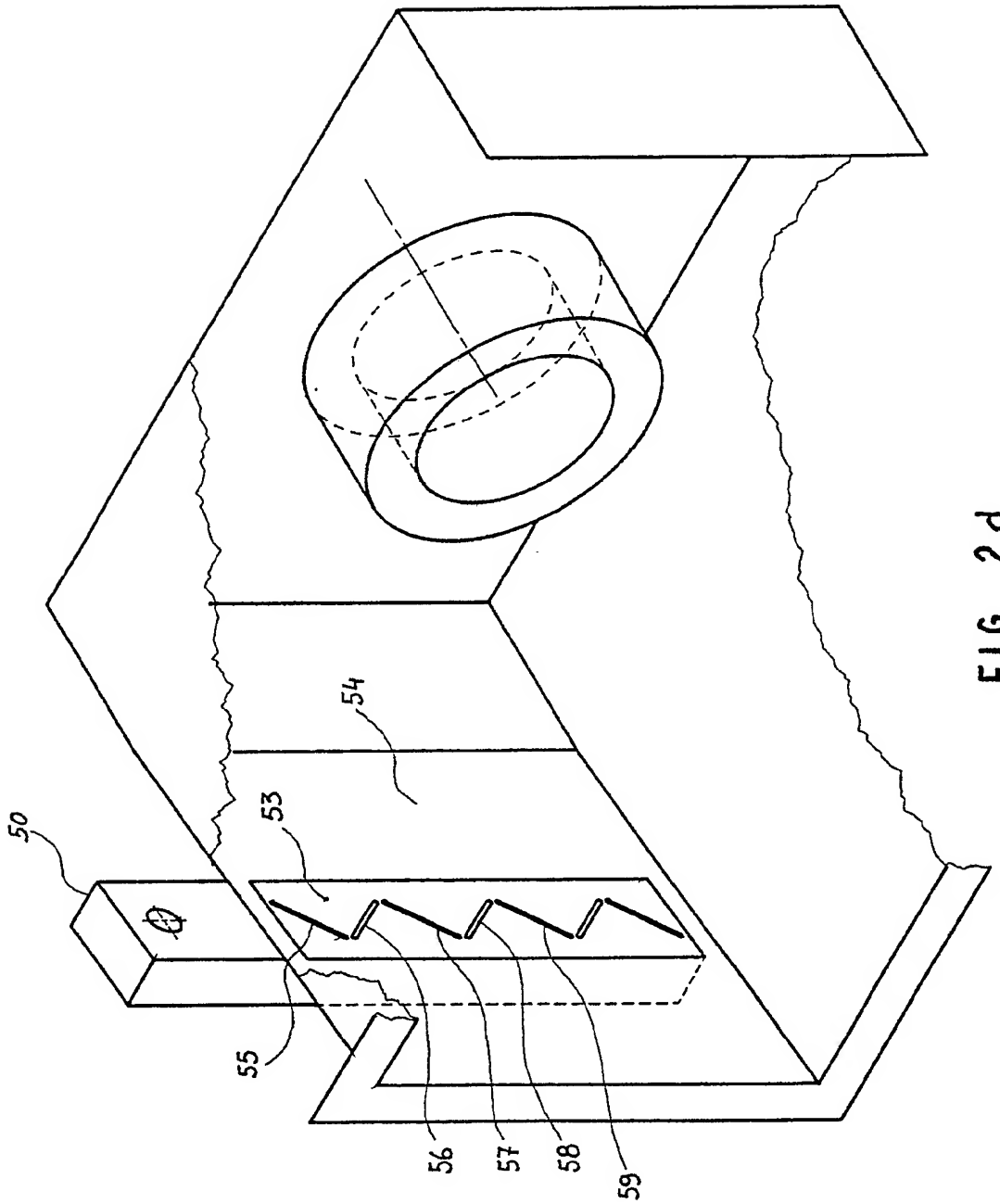

FIG. 2d

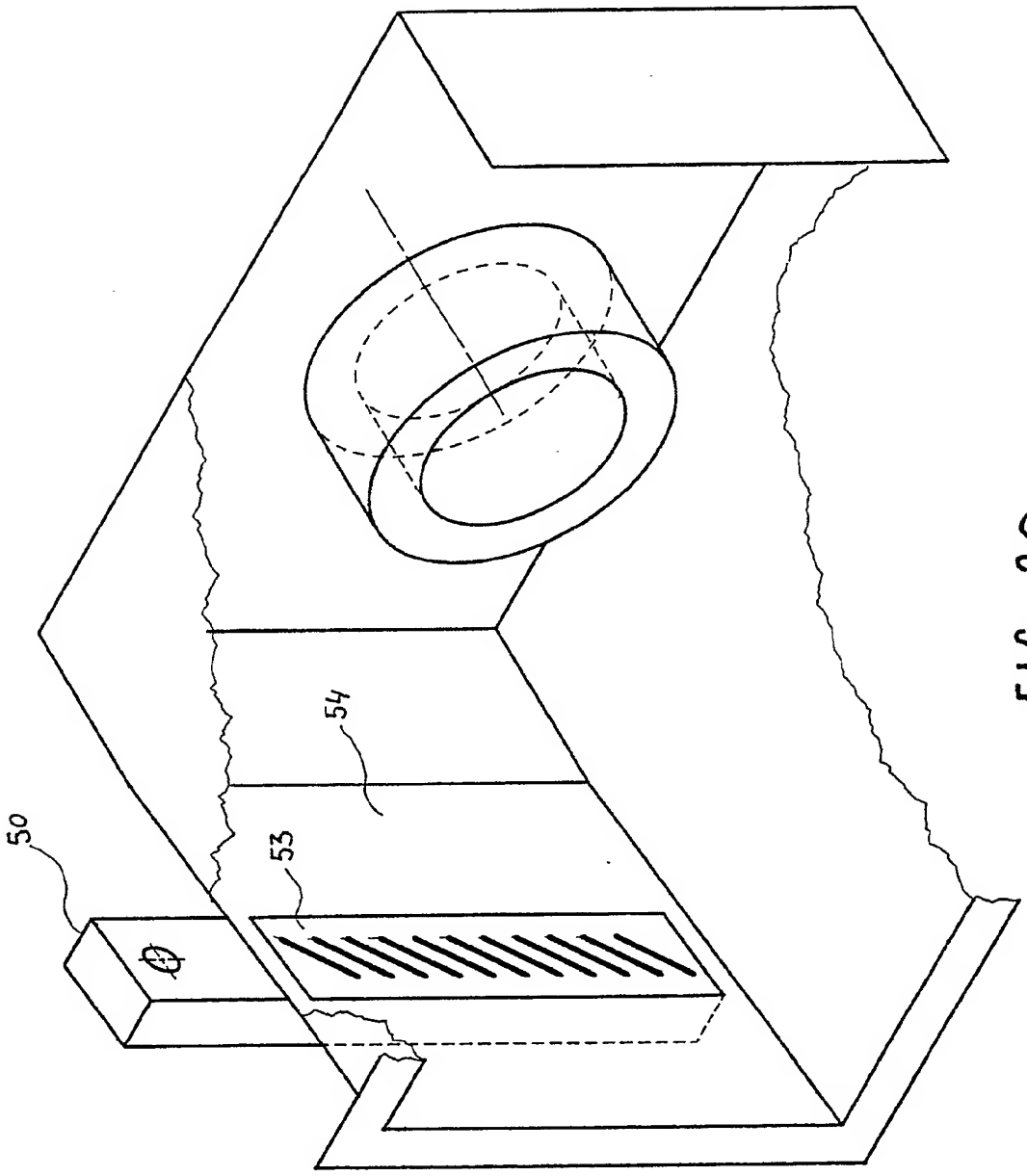

FIG. 2e

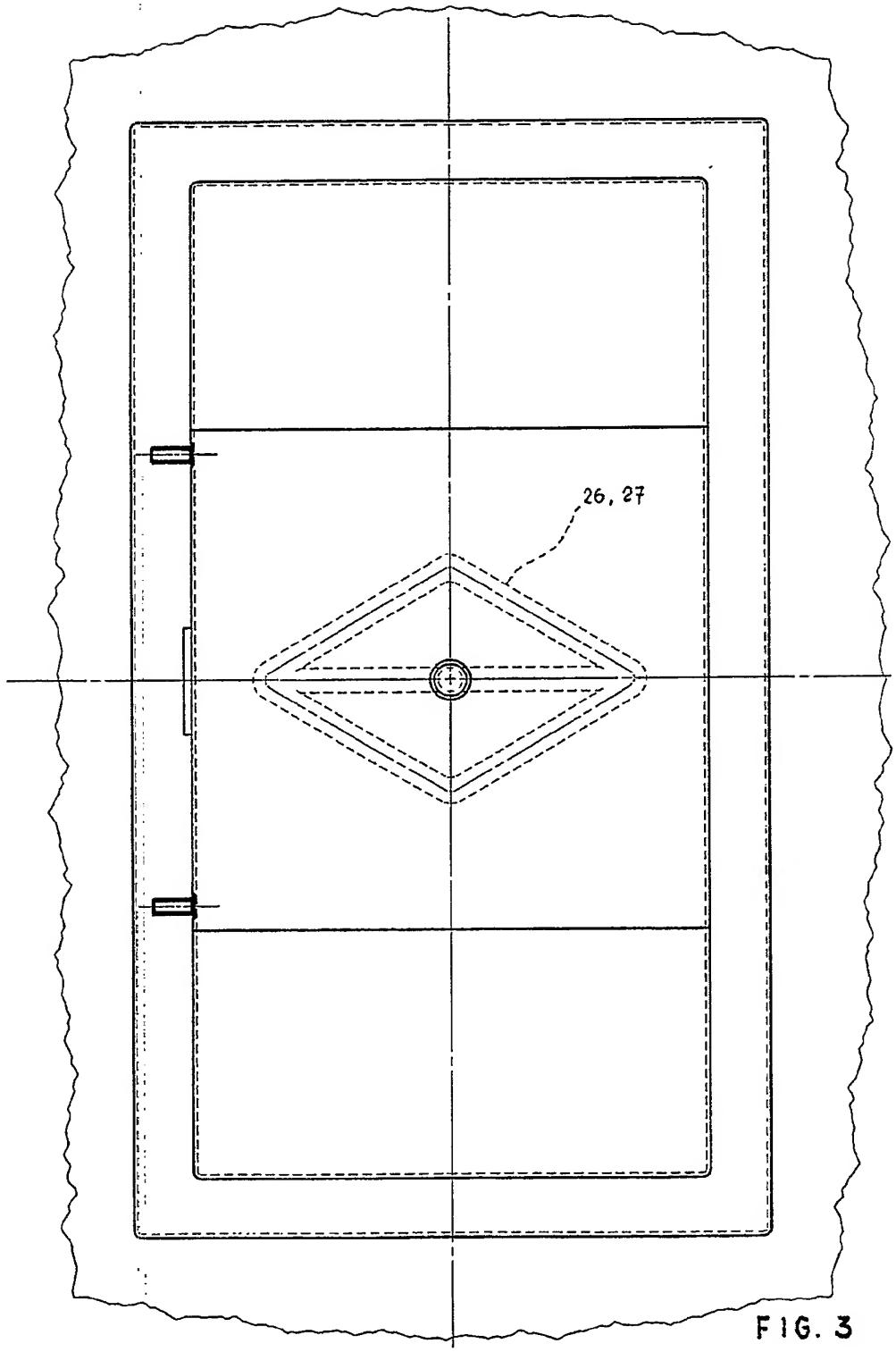

FIG. 3

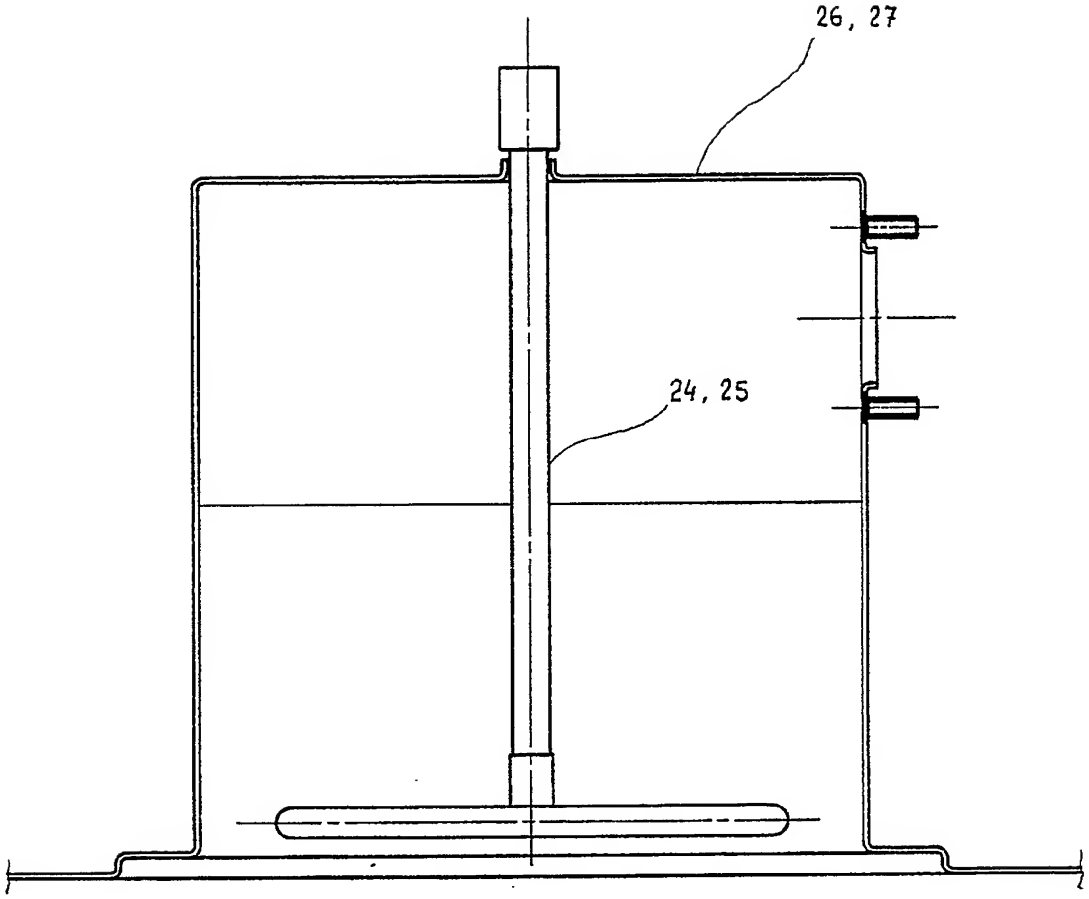

FIG. 4

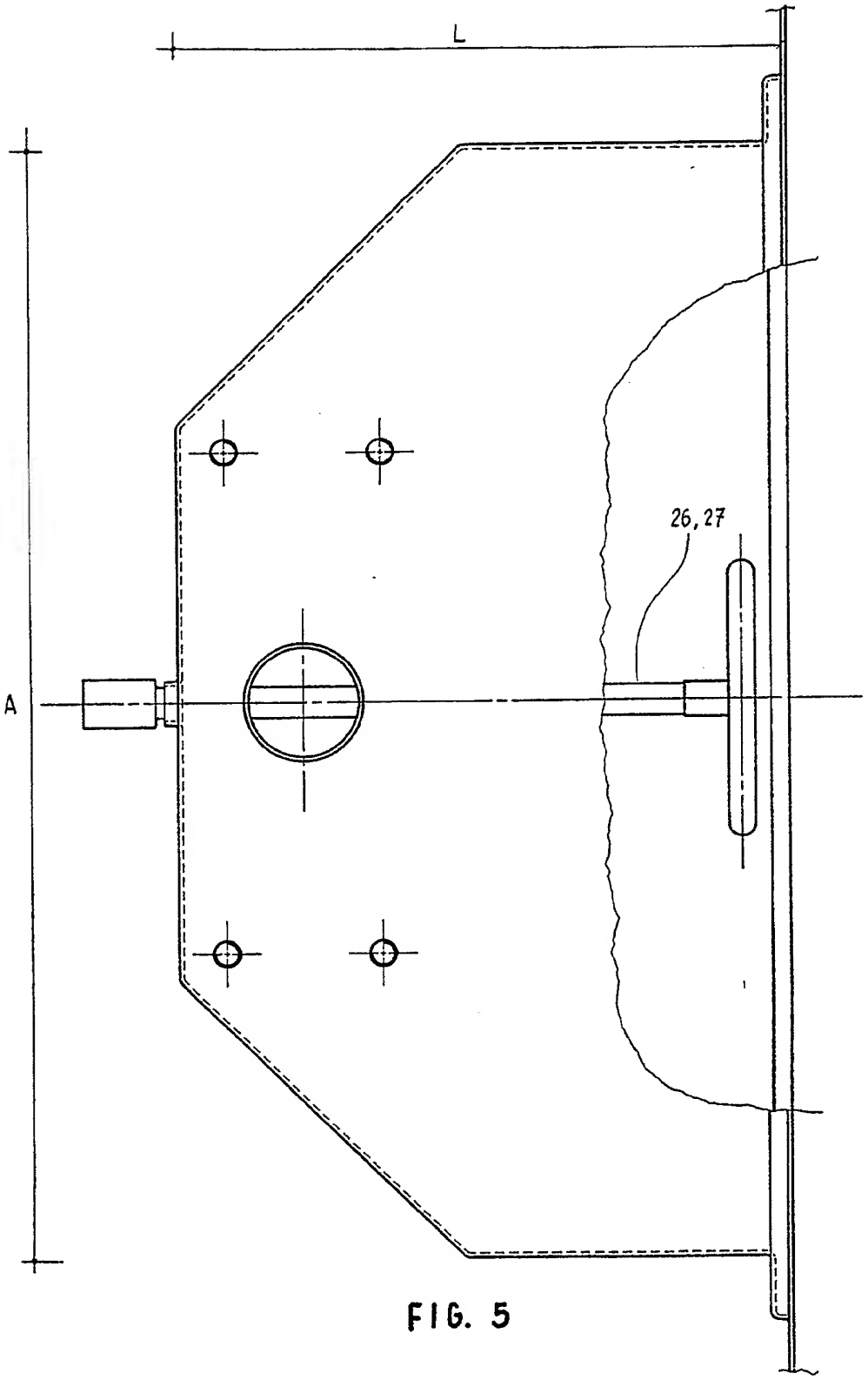

FIG. 5

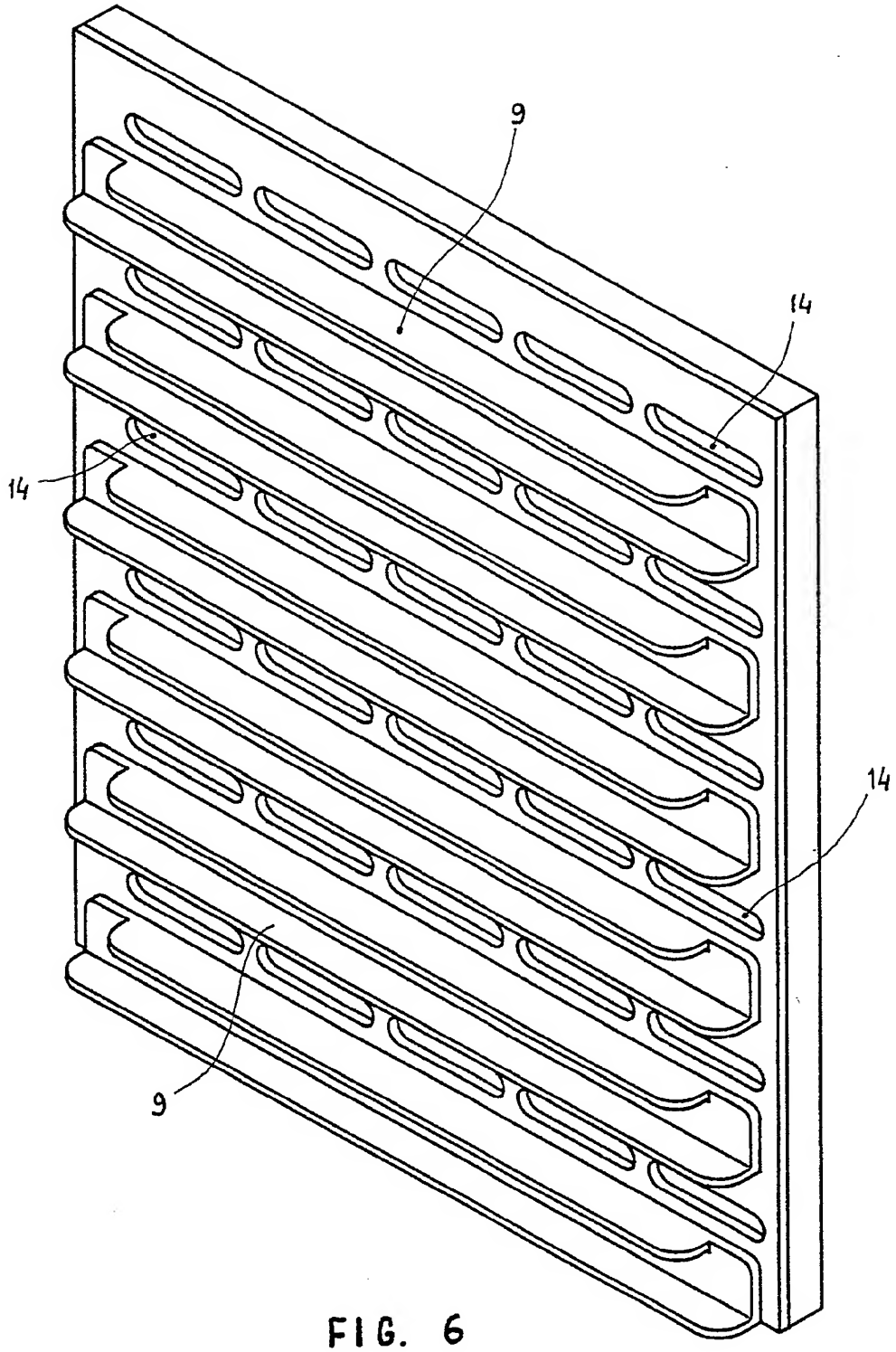

FIG. 6

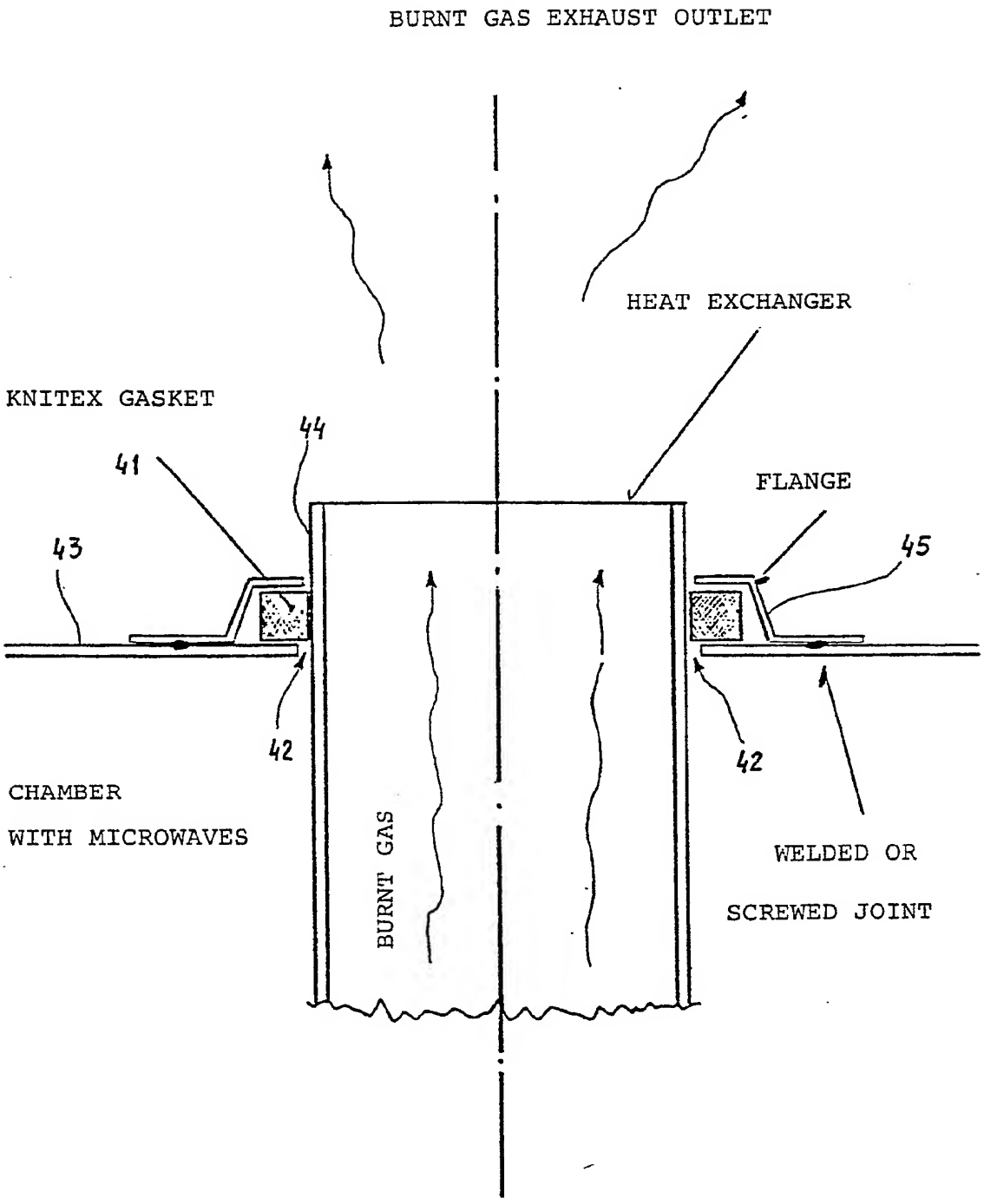
BURNT GAS EXHAUST OUTLET
HEAT EXCHANGER
KNITEX GASKET
44
41
FLANGE
43
45
42
42
CHAMBER
WITH MICROWAVES
BURNT GAS
WELDED OR
SCREWED JOINT

FIG. 7

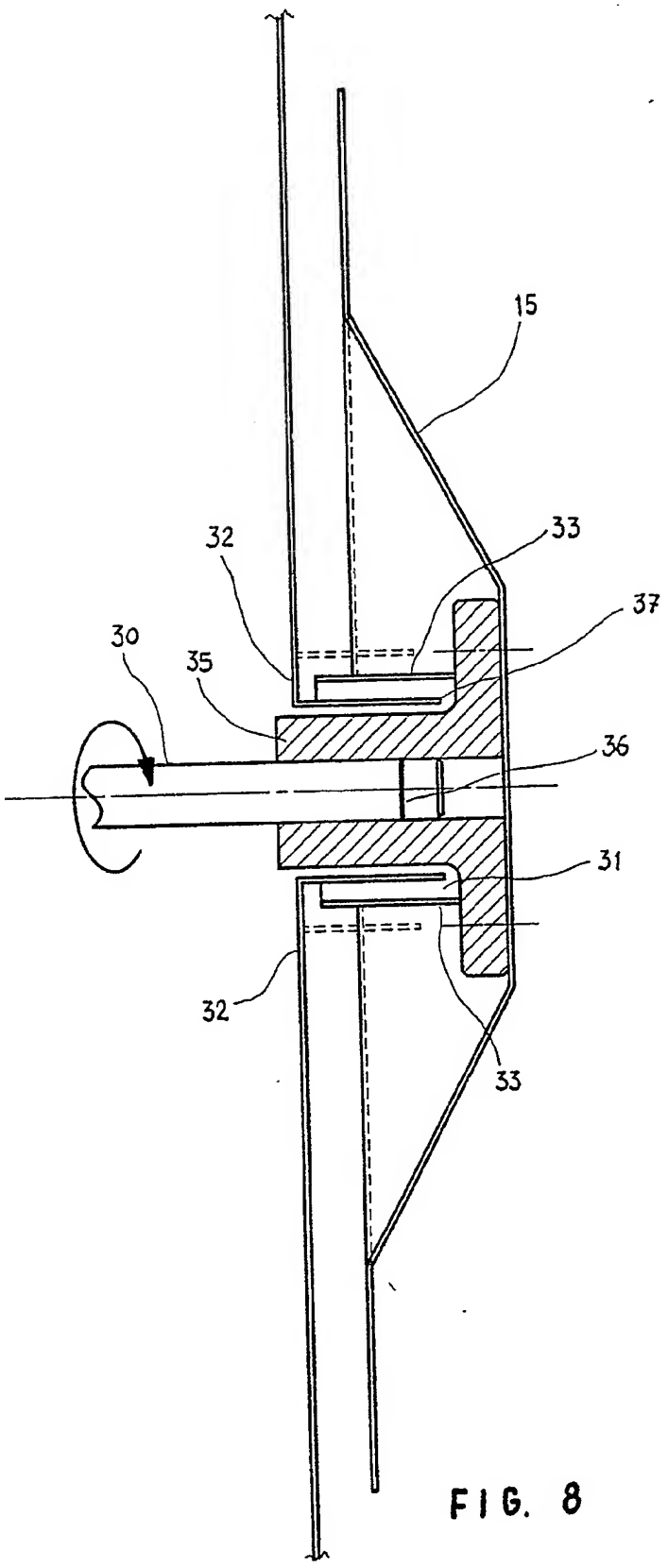

FIG. 8

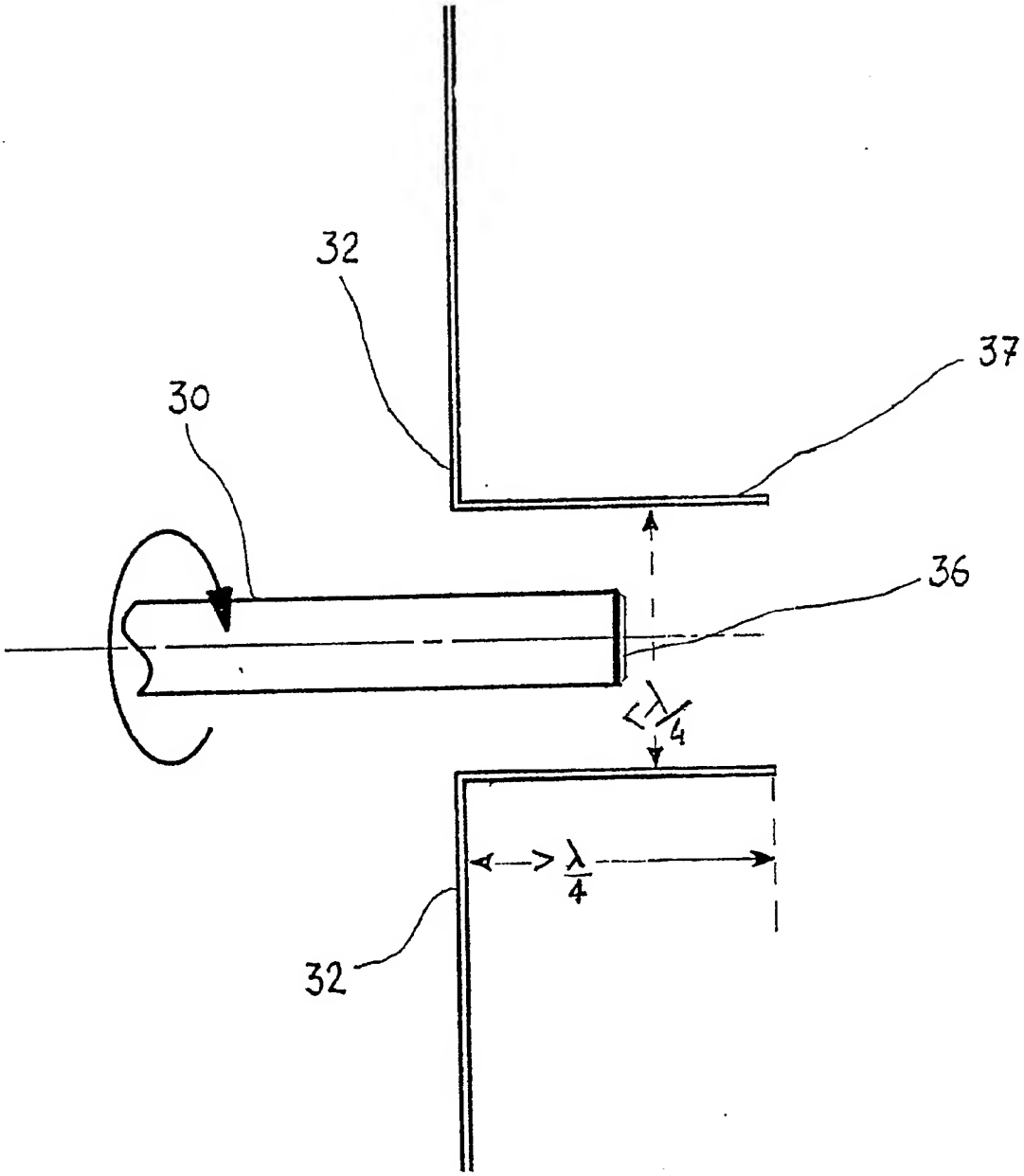

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number

EP 90 11 9715

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 140 888 (BARON ET AL.) * column 2, line 7 - column 3, line 17; figures 1, 2 *	1,3,5,9	H 05 B 6/80
A	US-A-4 329 557 (STAATS) * column 3, line 25 - column 5, line 23; figures 1, 2 *	1,9	
A	US-A-2 593 067 (PERCY L. SPENCER) * column 2, line 23 - column 4, line 19; figures 1, 2 *	1,2,10	
A	US-A-4 409 453 (DONALD P. SMITH) * column 5, line 40 - column 6, line 48; figures 2, 3 *	1,10	
A	US-A-2 704 802 (JUDD BLASS ET AL.) * column 1, line 80 - column 3, line 2; figures 1-5 *	1,5,6,8	
A	US-A-4 211 909 (YOSHIDA ET AL.) * column 4, line 12 - column 6, line 16; figure 3 *	1,12	
A	FR-A-2 119 479 (N.V. PHILIPS' GLOEILAMPEN-FABRIEKEN)		
A	FR-A-2 375 791 (RAYTHEON COMPANY)		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	FR-A-2 531 828 (REMY ROGER)		H 05 B
A	FR-A-2 446 993 (RAYTHEON COMPANY)		
A	DE-A-3 104 627 (LICENTIA PATENT-VERWALTUNGS-GMBH)		

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	06 March 91	RAUSCH R.G.

CATEGORY OF CITED DOCUMENTS

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